STOEBE VULGARIS, A STUDY OF AN ECOLOGICAL PROBLEM.

(With Plates VI and VII.)

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A study of *Stoebe vulgaris* was prompted in the first instance by the fact that it had become a nuisance of some importance, a weed which had covered considerable areas and was widely spread. Further, one school of thought believed it to be an indicator of moisture, while another school regarded it as an indication of over-grazing, or as a pioneer on denuded areas.

A search for suitable methods of eradication was not a difficult one, but in his study of the plant, the writer could not but be influenced by the atmosphere in which he was working. Most of this investigation was carried out at Frankenwald, the University of the Witwatersrand's Botanical Research Station, and here a number of experiments on natural veld treatment were in being. Many of the experiments were long term tests. In these circumstances, the writer was bound to have his attention drawn towards the ecological role of the plant he was studying. He felt that the problem of *Stoebe vulgaris* should be set against the problem of a special type, a grass community upset by over-grazing. Looking upon the plant community as a whole, any single, isolated plant could have no meaning without a study of that function represented by other members of the community. Further, a study of the role of particular plants like *Stoebe*, which, it became clear, was associated with certain fairly definite conditions, could not but yield valuable information in the management of natural veld. Thus an investigation of the whole complex of water relations, in relation to light, to carbohydrates and so on, gives a better understanding of such relationships as being the result of change, and as initiating the reactions which finally make for competition, succession. It is, in other words, an investigation of the "functional" aspect, (Clements, p. 7, 1916).

The plant then, is individualistic as a "type" problem, but at the same time is conditioned by its relationship to the community. A pioneering community will be built up in accordance with local needs. Ecology cannot be left as a mere matter of filling in successional lines, where so much experimentation is needed to supply explanation. For instance Phillips (1931) gives an account and a division of the Knysna forests into their seral and climax types, but he also divides them into types dependent on the water content of the soil (1928). In something of the same way, the writer hoped by his work on seeds of plants associated with *Stoebe*, or whose ecological habit was familiar, to throw some light on the relationship between their behaviour under laboratory germinating conditions, and their expected behaviour in the veld. Yapp (1922), criticising Clements (1905) for recommending that an accurate study of the habitat should come first, and the plant afterwards, writes, " In intensive work, it is not until the physiological problem has been defined, that the habitat factors can be studied intelligently and profitably."

To sum up, it is felt that only a thorough-going investigation of a community, from its formation to equilibrium, from ecesis to the physiological cycles of mature plants, can give a thorough understanding of the plant community that applied ecology needs. Nothing like this ambitious plan has been fulfilled in this study.

GERMINATION OF SEEDS.

Seeds were always germinated on filter paper, kept moist by strips of blotting paper suspended over a reservoir of water. The seeds were never sterilized before testing, except in one instance where a lot of *S. vulgaris* seeds were washed in 1/100 Mercuric chloride solution, and this appeared to damage them. At first, the filter paper and the blotting paper were sterilized in a flame, but this was discontinued as unnecessary. With the exception of the seeds of *Dicoma Zeyheri*, which were parasitised by a species of Pythium, all fungal spores were superficial. At temperatures higher than room temperature, and 35° C., and 40° C., the blotting paper had to be changed every five to seven days.

The tests at 35° C., dark, were carried out in an ordinary incubator, where the temperature varied about a degree above or below. The tests at 35° C., light, were carried out on a thermostatically controlled water bath. The tests at 40° C., in a germinator of the type used for growing cuttings or young plants, and the temperature control was poor. At these high temperatures evidences of super-saturation were apparent.

After collection, the seeds were left to dry for a few days, generally about three, before selection for the germinators.

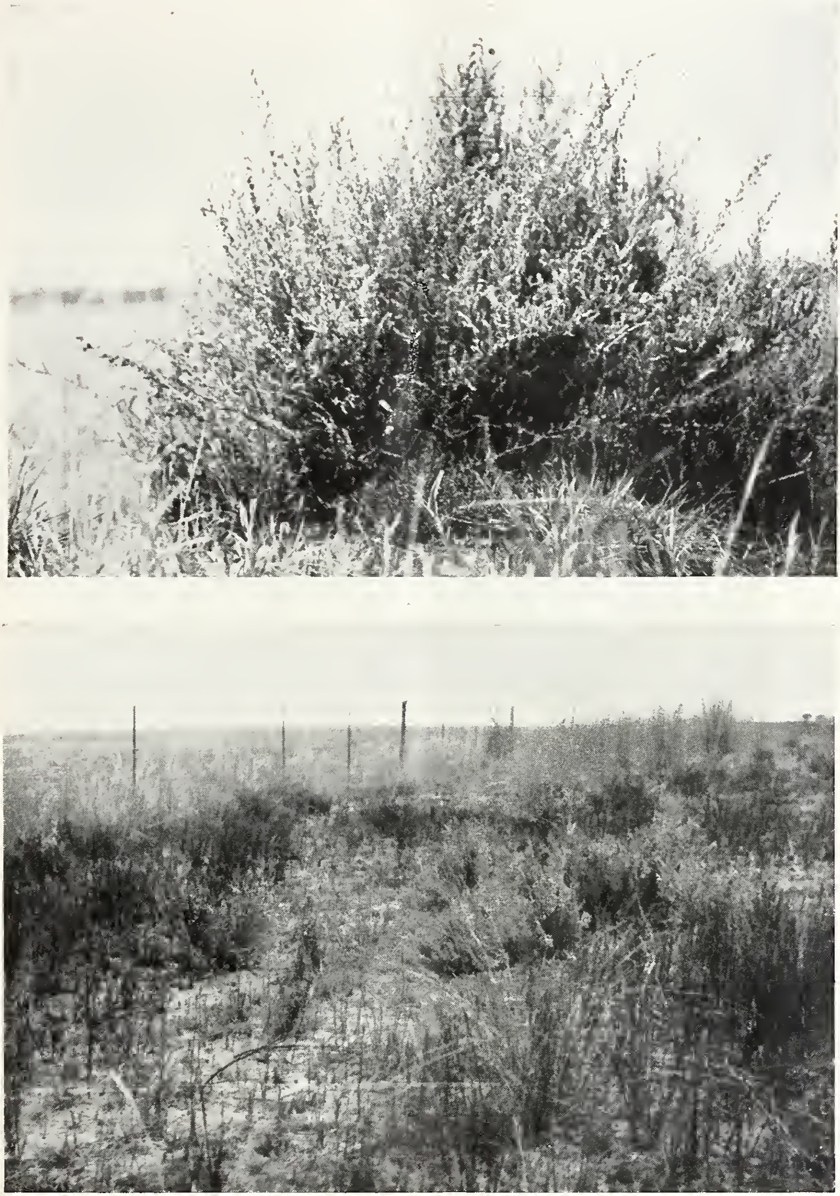

PLATE VI. A. A plant of *Stoebe vulgaris*.
B. *Stoebe vulgaris* on a ploughed fire belt.

Journal of S.A. Botany. (*To face p.* 80.)

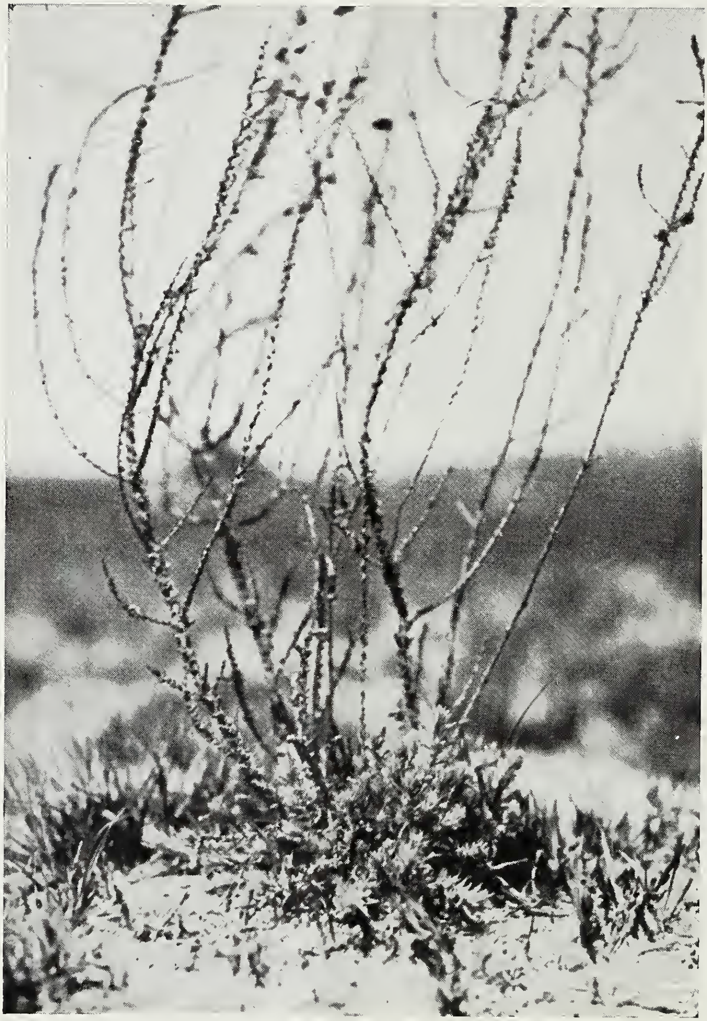

PLATE VII. *Stoebe vulgaris*; regeneration after burning.

Journal of S.A. Botany. (*To face p. 81*).

It appeared from tests that *Stoebe* seeds lost a measure of their viability with the passing of time, but they were able to germinate successfully soon after collection. 1,469 1934 *Stoebe* seeds when tested in 1935 at room temperature, gave a germination percentage of 48·7, while 1,000 1935 seeds gave 80 per cent. In 1936, two lots of seed were collected, one at the end of March, and one at the end of June. 450 and 800 seeds were included in the tests, respectively, and gave germination returns of 60·5 and 63·6 per cent.

Seed varied considerably in its germinating power. Three samples were collected on Frankenwald in April from different sites; the samples yielded 150, 150 and 20 seeds. None were viable. Seed was collected from the Government farm at Leeuwkuil near the Vaal, and from bushes on the banks of the Vaal. There was no seed in the Leeuwkuil lot, and 150 seeds from the Vaal bushes did not germinate. In early June another sample from Frankenwald did not germinate (100 seeds). There appeared to be some rough relationship between weight and germinating capacity. Below a weight of about 0·0037 grammes per 100 seeds, there was no germination. However, 1934 seeds germinated in 1935 weighed less than this, and yet germinated 40 per cent., and some 1936 seed that germinated was below this weight.

Some pre-germinator tests for viability were made, such as soaking in water and selecting seed that sank, and testing seed that remained on the surface; by a method suggested by Baldwin (1932), of leaving seeds in 95 per cent. alcohol for four minutes. Both these methods gave moderately satisfactory results. It was found later that a week in alcohol did not decrease germination.

Top seeds at end of one day, 20% germination.
Top seeds at end of four days, 27% germination.
Bottom seeds at end of one day, 70% germination.
Bottom seeds at end of four days, 52% germination.

Germination appeared to be a little delayed in the bottom seeds. The seeds that remained on top of the alcohol gave no germination for new or old seeds, but the other seeds that had sunk returned 78% and 52% respectively, from a sample that had given 97% and 60% when tested in the ordinary way.

Some attempts were made to germinate seeds on soils of different water contents. In a test lasting sixty days the following result was obtained: 90% M.W.R.C., 45% germination; 75% M.W.R.C., 37·5% germination; 66% M.W.R.C., 25% germination; 45% M.W.R.C., 9% germination.

Seeds were planted at different depths in soils of different M.W.R.C.'s, on the surface, and at $\frac{1}{4}$ inch and $\frac{1}{2}$ inch depths, and kept at 45% or 90% M.W.R.C. In river sand germination was obtained at all depths, and on the surface of the 90% M.W.R.C. of an 80% soil.

INFLUENCE OF AERATION ON STOEBE SEEDS.

Seeds were placed in tubes of distilled water and corked. Over a period of twelve months the water was changed twice. At the end of that time 60% of the 1934 seeds and about 80% of the 1935 seeds had germinated and put out small, stunted leaves.

Seeds were placed in small bottles and sealed. 1 c.c. of water was allowed to a seed. Germination took place in varying degrees over nine months.

Seeds were placed on thin agar ($2\frac{1}{2}$ g. to 250 c.c.s), and on the bottom of petri dishes and agar poured over them. Twenty-five seeds were placed in each dish. The result over a period of two months was as follows :

1935 seed on agar 56%, below agar 44%.
1934 seed on agar 48%, below agar 20%.

A number of other tests were made with CO_2 and O_2 impregnated atmosphere, and it was found that while severe doses of CO_2 induced narcosis, the seeds could germinate with relatively restricted oxygen. It may be mentioned, however, that seeds soaked overnight and placed for a day in a CO_2 atmosphere suffered no inhibition, nor did seeds soaked overnight and then placed in CO_2. For a discussion of dormancy, respiration, and permeability of seed coats, reference may be made to the papers of Rhine (1924), Shull and Davis (1923), Davis (1927) and (1930), Ranjan and Mallik (1931), Stiles and Leach (1933).

HEATING AND DRYING OUT OF SEEDS.

1934 and 1935 seed (in 1935) were kept dry at 30° C., for two weeks, which adversely affected the germination of the latter, but not the former year class.

After two days at 70° C., in an oven, 1935 seed lost 25% of their weight, and 1934 seed 36%. Germination was 56% and 26% respectively. In order to avoid the heating effect, seed was dried over Lithium chloride for one and two weeks. The weight loss was then 22% and 14·3%, and 43·8% and 50%. Germination of the new seed was delayed, but the old seed appeared to be slightly stimulated. Seed was frozen overnight and thawed during the day. Germination was 65% for 1935 seed and 56% for 1934 seed. In each case about one-fifth of the sample became mouldy on the germinators.

CHEMICAL TREATMENT OF SEED.

Seeds were soaked for 24 hours in 1% HCl, 1% H_2SO_4, and 1% Acetic acid. The old seeds were more resistant to the action of acids. Seeds treated with solutions of NaOH and KOH burst, and a brown colouring matter was extracted from them, which appeared to indicate a tannin when chemically tested. Shull and Shull (1924) mention the bursting of the middle layer of the coats of their seeds by KOH and NaOH, and also the possibility of interference by tannins in absorption and the removal of tannins by hydrates.

GERMINATION AND pH.

Seeds were placed on acid and alkali media, a ·5% by volume solution of HCl and KOH. Of course, these are strong solutions and not comparable, anyway. No new seeds germinated on the acid, and only 12% of the old, and 10% of the old on the alkali. A series of phosphate buffer solutions was also started, giving pH values from 4·5 to 8·3. No germination was obtained, though it might be mentioned that 84% germination was obtained for onion seeds at pH 5.

EFFECT OF POISONS ON STOEBE SEEDS.

Tested Stoebe seeds with Sodium and Potassium chlorate, which were used for eradication of the plant. Soaking in 5% solutions for one day had no effect. Soaking for one week in 10% and 20% solutions killed the seeds. Seeds were sown on the surface of small tins of soil. The tins were watered three times with 10% and 20% solutions of Sodium chlorate, and after this kept near saturation point with tap water. The amount of soil was about 700—800 grammes, and the amount of poison 150 c.c.s. No seeds germinated.

GERMINATION ON NUTRIENT MEDIA.

Seeds were grown on germinators, the reservoirs of which were filled with a steam extract of Frankenwald soil. Germination was good. Nutrient media were selected from Fred's book, Knops solution was used, a medium suggested by Tottingham, another by Shive. The seeds did not germinate, more than a few per cent.

RESPIRATION.

Respiration was tested in a crude way by drawing CO_2 free air over the seeds into a Pettenkofer tube filled with Baryta water and Barium chloride. 1935 seeds respired to 1934 seeds in the ratio of 1·2 : 1, making a correction for weight differences. 250 seeds were used in each test.

Seeds were allowed to absorb a little water, when respiration increased about five times.

EFFECT OF LIGHT ON GERMINATION.

It was found that the seeds could germinate in the dark. Seeds were placed in direct sunlight for a month, being removed to the laboratory over-night. This reduced germinative capacity, 1935 seed giving 62%, and 1934 seed 31·5%. When seeds were exposed dry, to direct sunlight, the resulting tests gave 69% for 1935 seed, and 13·5% for 1934 seed. As the experiment took place in winter time, high temperature does not seem to have been an important factor.

INFLUENCE OF TEMPERATURE.

Room temperature was the most favourable of all the temperatures used, but it must be remembered that room temperature is an alternating temperature. A series was run on soil, which had a M.W.R.C. of 30%. The tins were kept to water contents of 40%, 60%, 75% and 90%, and placed in the sun, under a 60 watt electric lamp, and in the dark, and in all the temperature was maintained at abour 31° C. In the table below, the result of the experiment is given.

	Sun.	Electric light.	Dark.
90%	10%	10%	12%
75%	60%	60%	28%
60%	52%	52%	20%
40%	12%	12%	40%

Only 35 seeds were used in each tin, a small number.

Temperatures of 30° C., and 35° C., inhibited germination, but 31° C. was chosen because it happened to be easy to maintain. When it was found that temperatures as low as 30° C. inhibited the germination of *Stoebe* seeds, there was another reason for testing the germination of other local weeds and grasses.

GERMINATION OF STOEBE, GRASS AND WEED SEEDS.

It was realised that temperature alone did not constitute the sole factor in germination, but the range of temperature was a point of great interest. Further, some rough tests were also made for light sensitivity, by germination in the dark. Also, it was desired to study such plants as might seed, for instance, on bare ground.

As many as possible were used in a test. The seeds were weighed in the form that it was thought they would be dispersed in. All the seeds fell into a few morphological classes. The total data was analysed under the headings of time and place of collection, number in test, date of first germination and number, and total germination expressed as a percentage with the time of the test, the weight of the seed, and any remarks such as special treatment given. Here, however, only the name and percentage of total germination will be given, and the date of collection.

At Room Temperature. Tests in 1936, unless otherwise stated.

Asclepiadaceae.	*Asclepias fruticosa* 1934, 0%. 1936, 0%
Amarantaceae.	*Gomphrena decumbens* 1936, 24%.
Chenopodiaceae.	*Chenopodium album* 1936, 15%.
Compositae.	*Bidens pilosa* 1934, 98·8%. 1936, 0%.
	Conyza ambigua 1936, 85·2%.
	Dicoma Zeyheri 1936. 0%.
	Dimorphotheca spectabilis 1934, 52%.
	Senecio serrata 1936, 65%.
	Stoebe vulgaris 1934 tested in 1935, 48·6%. 1934, 46%. 1935 in 1935, 80%. 1935, 79·2%. Frankenwald, 20th March 1936, 60·5%. April 23rd, 56%. April 23rd and April 28th, 0%. April 30th, 12%. June 11th, 0%. June 18th, 63·6%. Rietkuil, April 24th, 4%. Vaal, April 24th, 0%.
	Stoebe plumosa 1936, 0%.
	Vernonia kraussiana 1934, 0%.
	Helichrysum callicomum 1934, 0%. 1936, 0%.
Cruciferae.	*Capsella bursa-pastoris* 1934, 71%.
Cucurbitaceae.	*Cucumis sp.* 1934, 100%.
Iridaceae.	*Gladiolus edulis* 1936, 0%.
Leguminosae.	*Acacia karroo* 1936, 20%.
	Cassia mimosoides 1934, 0%.
	Indigofera sp. 1936, 0%.
	Rhynchosia nervosa 1936, 0%.
	Sphenostylis angustifolia 1934, 0%.
Liliaceae.	*Anthericum Macowani* 1936, 0%.
Plantaginaceae.	*Plantago dregeana* 1934, 5·5%.
Polygalaceae.	*Polygala abyssinica* 1936, 40%.
Rubiaceae.	*Oldenlandia amatymbica* 1934, 79%.
	O. herbacea 1934, 0%.
Solanaceae.	*Datura stramonium* 1934, 0%.
	Solanum capense 1936, 0%.
Umbelliferae.	*Peucedanum magalis-montanum* 1934, 0%.
Gramineae.	*Alloteropsis semi-alata* 1934, 45%.
	Andropogon amplectens 1934, 6%. 1935, 0%.
	A. huillensis 1934, 0%.
	A. eucomis 1934, 0%. 1936, 0%.
	Anthephora pubescens 1935, 0%.
	Aristida welwitschii 1934, 0%.
	A. barbicollis 1934, 53%. 1935, 0%. 1936, 0%.
	A. Burkei 1935, 8%.
	Arundinella Ecklonii 1934, 0%.
	Avena fatua 1934, 52%.
	Brachiaria serrata 1934, 5%. 1936, 0%.
	Cenchrus ciliare 1934, 0%.
	Chloris virgata 1935, 54%.
	Cynodon dactylon 1935, 0%.
	Cymbopogon excavatus 1935, 0%.
	C. plurinodis 1935, about 75% of the very few grains available. 1936, 0%.

Digitaria monodactyla, 0%.
Digitaria tricholaenoides 1934, 0%.
Diplachne biflora 1935, 0%.
Echinochloa pyramidalis 1935, 0%.
Eleusine indica 1934, 6%.
Elionurus argenteus 1934, 0%. 1936, 6%.
Eragrostis annulata 1935, 8%.
E. brizantha (?) 1935, 10%.
E. brizoides 1934, 90%. 1935, 28%. 1936, 70% about.
E. chalcantha 1934, 60%. 1936, 50%.
E. chloromelas 1935, 0%.
E. gummiflua 1934, 26%. 1936, 98%.
E. nebulosa 1935, 92%.
Eustachys paspaloides 1934, 64%.
Harpechloa falx 1934, 5%. 1936, 14%.
Heteropogon contortus 1934, 36% about.
Hyparrhenia aucta 1934, 30% about. 1935, 0%. 1936, 27%.
H. hirta 1934, 50% about. March 1936, 0%. April 1936, 56%.
Lophacme digitata 1935, 0%.
Loudetia simplex 1934, 0%.
Monocymbium ceresiiforme March 1936, 0%. April 1936, 0%.
Panicum natalense 1935, 73%. 1936, 42·5%.
Paspalum dilatatum 1934, 18%. 1936, 0%.
Pennisetum geniculatum 1935, 2%.
P. purpureum 1935, 0%.
Perotis indica 1935, 58%.
Pogonarthria falcata 1934, 37%.
Rhynceletrum roseum 1934, 96%. 1936, 12%.
R. setifolium 1935, 63%.
Setaria aurea 1934, 20%.
S. Lindenbergiana 1934, 0%.
S. nigrostis 1935, 51%.
Sporobolus indicus 1935, 99%.
Themeda triandra 1934, 32%. 1936, 0%.
Trachypogon plumosum 1935, 76% about. 1936, 0%.
Tristachya Rehmanni 1935, 18%.
Urelytrum squarrosum 1934, 0%.

Where "about" is added to the percentage germination, this indicates that the number of seeds in the test was small.

GERMINATION AT 35° C. IN THE LIGHT.

Asclepidaceae.	*Asclepias fruticosa* 1936, 53%.
Amarantaceae.	*Gomfrena decumbens* 1936, 48%.
Chenopodiaceae.	*Chenopodium album* 1936, 61%.
Compositae.	*Bidens pilosa* 1934, 95%. 1936, 82%.
	Conyza ambigua 1936, 78%.
	Dicoma Zeyheri 1936, 0%.
	Dimorphotheca spectabilis 1934, 8%.
	Senecio serra 1936, 16%.
	Stoebe vulgaris 1934, 28%. 1935, 53%. 23rd April, 1936, 6%. Vaal, 23rd April, 0%. April 30th Frankenwald, 28%. 11th June, 13%. 18th June, 14%.
	Vernonia kraussiana 1934, 3%.
	Helichrysum callicomum 1934, 0%. 1936, 0%.
	Xanthium spinosum 1936, 10%.
Cruciferae.	*Capsella bursa-pastoris* 1934, 82%.
Cucurbitaceae.	*Cucumis sp.* 1934, 0%.
Iridaceae.	*Gladiolus edulis* 1936, 0%.

Leguminosae.	*Acacia Karroo* 1936, 53%.
	Indigofera sp. 1936, 10%.
	Rhynchosia nervosa 1936, 0%.
Polygalaceae.	*Polygala abyssinica* 1936, 32%.
Rubiaceae.	*Oldenlandia amatymbica* 1934, 72%.
Ranunculaceae.	*Clematopsis Stanleyi* 1936, 0%.
Solanaceae.	*Datura stramonium* 1934, 27%.
	Solanum capense 1936, 0%.
Umbelliferae.	*Peucedanum magalis-montanum* 1934, 0%.
Gramineae.	*Alloteropsis semi-alata* 1935, 60%.
	Andropogon eucomis 1934, 0%. 1936, 4%.
	A. huillensis 1934, 2%.
	Aristida welwitschii 1934, 61%.
	A. barbicollis 1935, 44%. 1936, 10%.
	A. Burkei 1935, 16%.
	Arundinella Ecklonii 1934, 25%.
	Avena fatua 1934, 32%.
	Brachiaria serrata 1934, 32%. 1936, 0%.
	Cenchrus ciliare 1934, 2%.
	Chloris virgata 1935, 94%.
	Cynodon dactylon 1935, 0%.
	Digitaria monodactyla 1935, 1%.
	D. tricholaenoides 1934, 0%.
	Eleusine indica 1934, 35%.
	Eragrostis annulata 1935, 49%.
	E. brizantha 1935, 10%.
	E. brizoides 1935, 42%. 1936, 51%.
	E. chalcantha 1934, 33%.
	E. chloromelas 1935, 0%.
	E. gummiflua 1934, 90%. 1936, 56%.
	E. nebulosa 1935, 100%.
	Eustachys paspaloides 1935, 5%.
	Harpechloa falx 1934, 3%. 1936, 8·5%.
	Heteropogon contortus 1935, 80%.
	Hyparrhenia aucta 1936, 42%.
	H. hirta 1934, 10%. 1936, 52%.
	Lophacme digitata 1935, 0%.
	Loudetia simplex 1934, 0%.
	Monocymbium ceresiiforme 1936, 0%.
	Panicum natalense 1935, 47%. 1936, 0%.
	Paspalum dilatatum 1934, 1%. 1936, 0%.
	Pennisetum geniculatum 1935, 6%.
	P. purpureum 1935, 1%.
	Perotis indica 1935, 43%.
	Pogonarthria falcata 1934, 78%.
	Rhynceletrum roseum 1934, 42%.
	R. setifolium 1935, 76%.
	Setaria aurea 1934, 8%.
	S. Lindenbergiana 1934, 1%.
	S. nigrostis 1935, 44%.
	Sporobolus indicus 1935, 98%.
	Themeda triandra 1934, 53%. 1936, 3%.
	Trachypogon plumosum 1934, 4%. 1936, 12%.
	Tristachya Rehmanni 1935, 50%.
	Urelytrum squarrosum 1934, 12%.

Germination at 35° C. in the Dark.

Asclepidaceae.	*Asclepias fruticosa* 1936, 91%.
Amarantaceae.	*Gomphrena decumbens* 1936, 65%.
Chenopodiaceae.	*Chenopodium album* 1936, 35%.
Compositae.	*Bidens pilosa* 1934, 91%. 1936, 75%.

	Conyza ambigua 1936, 2%.
	Dicoma Zeyheri 1936, 0%.
	Dimorphotheca spectabilis 1934, 8%.
	Helichrysum callicomum 1934, 0%.
	Senecio serra 1936, 7%.
	Stoebe vulgaris 1934, 1%. 1936, 16%.
	Xanthium spinosum 1936, 0%.
Cruciferae.	*Capsella bursa-pastoris* 1934, 0%.
Cucurbitaceae.	*Cucumis sp.* 1934, 100%.
Iridaceae.	*Gladiolus edulis* 1936, 0%.
Leguminosae.	*Acacia Karroo* 1936, 66%.
	Indigofera sp. 1936, 36%.
	Rhynchosia nervosa 1936, 0%.
Polygalaceae.	*Polygala abyssinica* 1936, 20%.
Rubiaceae.	*Oldenlandia amatymbica* 1934, 44%.
Solanaceae	*Datura stramonium* 1934, 72%.
	Solanum capense 1936, 0%.
Umbelliferae.	*Peucedanum magalis-montanum* 1934, 0%.
Gramineae.	*Alloteropsis semi-alata* 1934, 55%.
	Andropogon amplectens 1935, 0%.
	A. eucomis 1934, 0%. 1936, 0%.
	A. huillensis 1934, 3%.
	Aristida welwitschii 1935, 65%.
	A. barbicollis 1935, 21%. 1936, 0%.
	A. Burkei 1935, 0%.
	Avena fatua 1934, 68%.
	Brachiaria serrata 1934, 44%. 1936, 0%.
	Chloris virgata 1935, 59%.
	Cynodon dactylon 1935, 0%.
	Digitaria monodactylon 1935, 1%.
	D. tricholaenoides 1934, 0%.
	Diplachne biflora 1935, 0%.
	Echinochloa pyramidalis 1935, 0%.
	Eleusine indica 1934, 4%.
	Eragrostis annulata 1935, 56%.
	E. brizantha 1935, 0%.
	E. chalcantha 1934. 19%. 1936 0%.
	E. chloromelas 1935 2%.
	E. gummiflua 1934, 92%. 1936, 24%.
	E. nebulosa 1935, 100%.
	Eustachys paspaloides 1935, 0%.
	Harpechloa falx 1934, 5%. 1936, 1·5%.
	Heteropogon contortus 1935, 72%.
	Hyparrhenia aucta 1935, 0%. 1936, 44%.
	H. hirta 1934, 20%. 1936, 44%.
	Lophacme digitata 1935, 0%.
	Loudetia simplex 1935, 0%.
	Monocymbium ceresiiforme 1936, 0%.
	Panicum natalense 1935, 59%. 1936, 0%.
	Paspalum dilatatum 1934, 1%.
	Pennisetum geniculatum 1935, 4%.
	P. purpureum 1935, 0%.
	Perotis indica 1935, test lost.
	Pogonarthria falcata 1934, 51%.
	Rhynceletrum roseum 1934, 66%.
	R. setifolium 1935, 74%.
	Setaria aurea 1934, 20%.
	S. nigrostis 1935, 64%.
	Sporobolus indicus 1935, 99%.
	Themeda triandra 1934, 75%. 1936, 2%.
	Trachypogon plumosum 1935, 8%. 1936, 0%.
	Tristachya Rehmanni 1935, 0%.
	Urelytrum squarrosum 1934, 4%.

GERMINATION AT 40° C. IN THE LIGHT.

Asclepidaceae.	*Asclepias fruticosa* 1936, 11%.
Amarantaceae.	*Gomphrena decumbens* 1936, 2%.
Chenopodiaceae.	*Chenopodium album* 1936, 39%.
Compositae.	*Bidens pilosa* 1934, 11%. 1936, 85%.
	Conyza ambigua 1936, 0%.
	Dicoma Zeyheri 1936, 0%.
	Senecio serra 1936, 1%.
	Stoebe vulgaris 1934, 0%. 1935 in 1936, 0%. Vaal April, 0%. Frankenwald 23rd April, 0%. April 30th, 0%. 11th June, 0%. 18th June, 0%.
	Vernonia kraussiana 1934, 0%.
Cruciferae.	*Capsella bursa-pastoris*, 1934, 0%.
Cucurbitaceae.	*Cucumis sp.* 1934, 0%.
Iridaceae.	*Gladiolus edulis* 1936, 0%.
Leguminosae.	*Acacia Karroo* 1936, 14%.
	Indigofera sp. 1936, 6%.
Plantaginaceae.	*Plantago dregeana* 1934, 100%.
Polygalaceae.	*Polygala abyssinica* 1936, 16%.
Rubiaceae.	*Oldenlandia amatymbica* 1934, 52%.
Solanaceae.	*Datura stramonium* 1934, 65%.
	Solanum capense 1936, 0%.
Umbelliferae.	*Peucedanum magalis-montanum* 1934, 0%.
Gramineae.	*Alloteropsis semi-alata* 1934, 35%.
	Andropogon amplectens 1935, 0%.
	A. eucomis 1934, 0%. 1936, 0%.
	A. huillensis 1934, 0%.
	Aristida welwitschii 1935, 1%.
	A. barbicollis 1935, 25%. 1936, 11%.
	A. Burkei 1935, 4%.
	Avena fatua 1934, 0%.
	Brachiaria serrata 1934, 10%. 1936, 0%.
	Cenchrus ciliare 1934, 0%.
	Chloris virgata 1935, 28%.
	Cynodon dactylon 1935, 0%.
	Digitaria tricholaenoides 1934, 0%.
	Eragrostis annulata 1935, 16%.
	E. brizoides 1934, 86%. 1935 in 1936, 80%. 1936, 82%.
	E. chalcantha 1934, 0%.
	E. chloromelas 1935, 5%.
	E. gummiflua 1934, 100%. 1936, 37·5%.
	E. nebulosa 1935, 95%.
	Eustachys paspaloides 1934, 28%.
	Harpechloa falx 1934, 13%. 1936, 6·5%.
	Heteropogon contortus 1935, 46%.
	Hyparrhenia aucta 1936, 34%.
	H. hirta 1934, 10%. 1936, 24%.
	Loudetia simplex 1934, 0%.
	Monocymbium ceresiiforme 1936, 0%.
	Panicum natalense 1935, 3%. 1936, 0%.
	Paspalum diltatatum 1934, 0%.
	P. purpureum 1935, 0%.
	Rhynceletrum roseum 1934, 64%. 1936, 0%.
	R. setifolium 1935, 38%.
	Schizachyrium semiberbe 1936, 8%.
	Setaria aurea 1934, 0%.
	S. Lindenbergiana 1934, 0%.
	S. nigrostis 1935, 9%.
	Trachypogon plumosum 1934, 4%.
	Tristachya Rehmanni 1935, 0%.
	Urelytrum squarrosum 1934, 6%.

ON SOIL AT AIR TEMPERATURE.

Asclepidaceae.	*Asclepias fruticosa* 1934, none in 34 days. None for 1936 seed.
Amarantaceae.	*Gomphrena decumbens* 1936, none in 44 days.
Chenopodiaceae.	*Chenopodium album* 1936, none in 47 days.
Compositae.	*Bidens pilosa* 1934, and 1936 seed, none in 44 days.
	Conyza ambigua 1936, none in 44 days.
	Dicoma Zeyheri 1936, none in 48 days.
	Dimorphotheca spectabilis 1936, none in 48 days.
	Senecio serra 1936, none in 34 days.
	Stoebe vulgaris, 1934, 1935 in 1936, none in 47 days. April 30th, June 11th, 1936, none in 39 days.
	Vernonia kraussiana 1934, none in 41 days.
	Xanthium spinosum 1936, none in 76 days.
Cruciferae.	*Capsella bursa-pastoris* 1934, none in 54 days.
Cucurbitaceae.	*Cucumis sp.* 1934, none in 59 days.
Iridaceae.	*Gladiolus edulis* 1936, none in 48 days.
Leguminosae.	*Acacia Karroo* 1936, none in 62 days.
	Indigofera sp. 1936, none in 53 days.
Polygalaceae.	*Polygala abyssinica* 1936, none in 54 days.
Rubiaceae.	*Oldenlandia amatymbica* 1934 in 1936, none in 54 days.
Solanaceae.	*Datura stramonium* 1934 in 1936, none in 48 days.
Umbelliferae.	*Peucedanum magalis-montanum* 1934 in 1936, none in 54 days.
Gramineae.	*Alloteropsis semi-alata* 1934 in 1936, none in 64 days.
	Andropogon amplectens 1935 in 1936, none in 57 days.
	A. eucomis 1934 in 1936, none in 62 days. 1936, none in 34 days.
	A. huillensis 1934 in 1936, none in 64 days.
	Aristida welwitschii 1934 in 1936, none in 59 days.
	A. barbicollis 1934 in 1936, none in 48 days. 1935 in 1936, none in 53 days. 1936, none in 34 days.
	A. Burkei 1935 in 1936, none in 71 days.
	Avena fatua 1934 in 1936, none in 64 days.
	Brachiaria serrata 1934 in 1936, none in 59 days. 1936, none in 66 days.
	Cenchrus ciliare 1935 in 1936, none in 64 days.
	Chloris virgata 1935 in 1936, none in 71 days.
	Cynodon dactylon 1935 in 1936, two tests, none in 53 or 65 days.
	Digitaria monodactyla 1935 in 1936, none in 71 days.
	D. tricholaenoides 1934 in 1936, none in 61 days.
	Echinochloa pyramidalis 1935 in 1936, none in 73 days.
	Eleusine indica 1934 in 1936, none in 77 days.
	Eragrostis annulata 1935 in 1936, none in 67 days.
	E. brizoides 1934 in 1936, 1935 in 1936, and 1936, none in 41, 59 or 59 days.
	E. chalcantha 1934 in 1936, none in 41 days.
	E. chloromelas 1935 in 1936, none in 65 days.
	E. nebulosa 1935 in 1936, none in 71 days.
	Eustachys paspaloides 1934 in 1936, none in 44 days.
	Harpechloa falx 1934 in 1936, and 1936, none in 63 or 34 days.
	Heteropogon contortus 1935 in 1936, none in 59 days.
	Hyparrhenia aucta 1936, none in 53 days.
	H. hirta 1934 in 1936 and 1936, none in 59 or 41 days.
	Lophacme digitata 1935 in 1936, none in 73 days.
	Monocymbium ceresiiforme 1936, none in 34 days.
	Panicum natalense 1934 in 1936 and 1936, none in 65 or 34 days.
	Paspalum dilatatum 1934 in 1936, none in 66 days.
	Pennisetum geniculatum 1935 in 1936, none in 76 days.

P. cenchroides 1934 in 1936, none in 39 days.
Perotis indica 1935 in 1936, none in 73 days.
Pogonarthria falcata 1934 in 1936, none in 76 days.
Rhynceletrum roseum 1934 in 1936, none in 73 days.
R. setifolium 1935 in 1936, none in 64 days.
Schizachyrium semiberbe 1934 in 1936, none in 48 days.
Setaria aurea 1934 in 1936, none in 60 days.
S. Lindenbergiana 1934 in 1936, none in 56 days.
S. nigrostis 1935 in 1936, none in 73 days.
Sporobolus indicus 1935 in 1936, none in 76 days.
Themeda triandra 1936, none in 76 days.
Trachypogon plumosum 1934 in 1936 and 1936, none in 62 days.
Urelytrum squarrosum 1934 in 1936, none in 34 days.

After 28 days at room temperature, 100 out of 215 *Asclepias fruticosa* 1936, were transferred to 35° C. light, and on the third day at that temperature the first germination occurred, and the total over 24 days was 47%. 100 seeds from the same room temperature test were placed for one week in an oxygenated atmosphere at room temperature, and gave 51% and a total of 74% germination in two weeks. The 1934 seeds which at room temperature had germinated only 3% in 41 days, gave 90% in 24 days at 35° C., and four germinations occurred on the third day. The seed appears to be light sensitive.

In the case of *Chenopodium album* 1936, after a small percentage germination at room temperature, the seeds were transferred to an oxygenated atmosphere for two weeks, but no germinations occurred, The coats were then pricked, and 70% germinated in one week. The seed appears to be light sensitive.

After being on a germinator at room temperature for 23 days, 100 1936 *Bidens pilosa* seeds were stepped up to 35° C., when they gave 13% in ten days. Seeds were treated with NaOH for four hours, and given five minutes in conc. H_2SO_4, but these treatments did not improve germination. 75 1936 seeds, after being 22 days at room temperature, were allowed to dry out for two days, and then had their coats pricked. In 17 days 26 germinations occurred. 100 seeds were taken from the air temperature germinators, and frozen and thawed for 6 days; they were then germinated at 35° C. light, and gave 84% in 56 days. The seeds are not sensitive to darkness.

100 1936 *Conyza ambigua* after 25 days at room temperature gave 85·2% germination. 100 of the remainder was stepped to 35° C. light, and on the third day there were 7 germinations, with a total of 74 in 23 days. Apparently also, light is needed for good germination.

100 1936 *Senecio serra* seeds after 30 days at room temperature were placed at 35° C. light, but no germinations occurred. A number of seeds were defective. The pappus is easily detachable.

Stoebe vulgaris was among the lightest of the seeds. It requires a moderate temperature for germination. It does not appear to be light sensitive.

After 51 days at room temperature, *Vernonia kraussiana* was stepped up to 35° C. light, but this did not produce any further germinations. Seeds from room temperature were also given the oxygen treatment without result.

100 1934 *Helichrysum callicomum* seeds after 36 days at room temperature were placed at 35° C. light, but no further germinations occurred.

Capsella bursa-pastoris is apparently inhibited at high temperatures, but at 35° C. light germination was normal, whereas in the dark at that temperature it was inhibited.

In *Cucumis sp.* germination is normal in the dark at 35° C.

After 25 days at room temperature, 25 *Gladiolus edulis* seeds were transferred to 35° C. light, when one more germinated.

In the case of *Acacia Karroo*, the tests took so long, that perhaps they were not complete when abandoned.

After 25 days at room temperature, 25 1936 *Indigofera sp.* seeds were placed at 35° C. light, but there were no further germinations.

At 35° C. *Datura stramonium* germinated best in the dark, in a most marked manner, but at 40° C. in the light, germination was normal. After being 35 days at room temperature, seeds were stepped up to 35° C. light, and after 27 days at this temperature, coats were pricked, but no further germinations occurred, whereas when the seeds were placed at 35° C. without any preliminary treatment, they gave 27% in 17 days.

Aristida Welwitschii seemed to like high temperatures, and the seeds were indifferent to light or darkness.

Aristida barbicollis did not germinate at high temperatures. Darkness depressed germination in *Aristida Burkei*, as did temperatures above 25° C.

Eragrostis chalcantha was a plant found to be associated with *Stoebe* in a fairly high frequency. Like *Stoebe* the germination is depressed at high temperatures, as compared with room temperature, and darkness also depressed germination.

Eragrostis nebulosa was associated with a wide range of temperature, and germinated well at high temperatures.

It may be noted that the seeds of *Panicum natalensis* were still germinating at room temperature when the test was discontinued on the 99th day.

In *Rhynceletrum roseum*, it appears that germination is increased by a lapse of two years after collection.

In the case of *Themeda triandra*, a great number of seeds were collected on the ground under the plants.

It must be noted that in these tests light sensitivity and photochemical reactions might easily be confused with temperature effects.

Lansdell states that she obtained over 60% germination of *Xanthium*, in one month on sawdust. I obtained no germination of burrs on soil or in any of the tests except 35° C. light. Perhaps the seed was not of the same year.

The seeds selected cut across ecological boundaries, but it was thought that this would lessen the risk of easy generalisation. In some cases there can be seen a correlation between germination behaviour under controlled conditions and ecological status, but frequently this cannot be seen. Germination tests of this nature are but a superficial indication of the behaviour of the seed under field conditions, and anyway, the tests are not complete. After laboratory experiments on the distance travelled by *Stoebe* seeds, one might be inclined to deprecate the distances likely to be covered by them, but actually *Stoebe* seedlings have been found at least half-a-mile from the nearest community, in the direction of the prevailing wind.

No results were obtained from seeds planted on soil. The soil was a fine clay, watered once or twice a day. Perhaps the temperature was too low. Seeds placed on soil and kept in a greenhouse germinated quite well, about half that obtained on germinators, in the case of *Stoebe*, one-third for *Rhyncelytrum roseum*, and half for *Conyza ambigua*.

EXPERIMENTS ON THE DISPERSAL OF STOEBE SEEDS.

Laboratory experiments were made with a three speed fan, and greased plates, and seed traps were also set up in the field, at varying heights, and different distances, at selected spots. These tests seemed to indicate that the seed would not be carried very far except in a very strong wind. Even then, a field survey seemed to indicate that the distance of seedlings from the parent community would be a comparatively short one, except in exceptional cases. Although the pappus has small hooks, the seeds do not cling with any persistence, and the pappus is easily detachable, when the seed is ripe. The pappus appears to have the minor role of a simple parachute. At the time that the seed becomes fully ripe, masses of seed intermingled with bracts will be found on bare ground under the parent plants.

There is no vegetative propagation ; no layering occurs, and broken portions of the stem, or the root stock, do not grow.

Several attempts were made, by prepared seed beds and selected cleared sites, to collect seedlings. Seedlings were first found when they were already fair sized plants, averaging 9 inches in height, in December 1933. They were first noticed on old roads, and ploughed belts. They were removed and grew quite well when transplanted. The history of the site was well-known, for at least the two previous years.

The seed beds served to emphasize that seedlings could only be expected in the direction of the prevailing wind. Mapping the shape of communities also showed the influence of the wind.

A number of transects were laid out by Gillman and continued by the author, but were not of much use in showing the movements of any of the communities mapped. However, owing to accidental fires, they were using in giving growth figures, and survival after burning.

Other experiments consisted in the laying of metre quadrats on sites where seedlings had been observed. The site was cleared of all vegetation. Another quadrat was heavily fertilized with 2½ lbs. of PNK. Another was laid on a heavily grazed experimental area, and sown with seed, and so on. No seedlings were found on these areas, but in September 1936, after a heavy fall of snow, a number of young seedlings were found on an old road. They varied in size from ½ inch to 1½ inches, excluding the root system which appeared to be 3—4 times as long again. The snow had fallen two weeks previously, and had given the ground a thorough soaking. It must be noted that the seed that had germinated must have lain dormant for several months. It appeared that *Stoebe* generally came into an area in comparatively small numbers, considering the enormous production of seed, and that, when conditions continued bad (say annual burning and premature grazing), the opportunity for further germinations was kept open.

Penetration by roots on ploughed land must be easy, and water penetration also, but then the surface will tend to dry out. It may be for this reason that *Stoebe* plants on such sites fail to assume good proportions until their second full year. On old roads, penetration by roots and water will be difficult, and the amount of run-off considerable. Some comparative figures were obtained for penetration, by the use of an iron cylinder, driven half into the ground, and filled with water. The sites were—under a fairly open *Hyparrhenia hirta* community, an old road, a ploughed belt, and a *Stoebe* community, and penetration was as follows, in minutes—23, 21, 12 and 10.

Stoebe seeds, then, were found to germinate well, as in 1932 when a drought broke, or in 1936 when there were late winter rains, and a fall of snow, which seems to have immediately preceded the germination of the seeds, which had probably been on the ground since the previous July.

SOIL TESTS ON SAMPLES FROM DIFFERENT STOEBE SITES.

A number of physical and chemical tests were applied to soil taken from various *Stoebe* sites.

The physical tests were, Maximum Water Retaining Capacity, Sticky Point, Colloids (Bouyoucos), and were taken from a hoed plot; (see eradication section), an old and dense community; a protected plot; from a site with shale, with some sandstone and quartzite, among *Stoebe* and beyond it: from a site with coarse quartzites, grits, conglomerates and shales (Elsberg series); from a Klipriversberg series adjacent to the above, with dolomitic limestones and amygdaloidal lavas where there was no *Stoebe*; from a Northern Transvaal granite area; from a Northern Transvaal sandstone-quartzite, sandy shale area. *Stoebe* occurs in the Transvaal on every geological formation.

Tests were also made of "humus", organic matter by ignition, pH values, nitrates, ammonium salts, and bacterial plates were made with coarse samples.

Quantitative tests were made for iron, aluminium, and phosphates. Qualitative tests were made for carbonates, calcium and magnesium. Exchangeable bases were determined by the method of Puri (1935).

It was not possible at the time to take proper samples for soil moisture, which would involve sampling to a depth of at least five feet, and the samples were relatively superficial. The M.W.R.C. method, with small brass boxes, is held to be a useful, if empirical method, for ecological reconnaissance, but has many faults. The Bouyoucos method for the determination of colloids measures what had best be called the fine clay content. Sticky point needs considerable practice for consistent results. The pH values were not determined for some months after collection, so that changes in the pH values may have occurred in that time. The pH value is often associated with leaching, but this is not invariably true. (Pearsall and Wray, 1927; Pierre, 1931.) Organic matter by ignition is quick and simple but not accurate. (Rather, 1918; Allison, 1935.)

The moisture contents, taken at random and rather isolated, are not very valuable. All the "physical" measurements show a wide range of variation. A soil sample was taken from the sand dunes along the Vaal, where there was an extensive *Stoebe* community. The soil had a pH of 7·01. This is not believed to indicate that it was "*Stoebe* soil." It might have happened that *Stoebe* as a plant was associated with certain physical characters, in soils, but these results seem to indicate that the variations indicate nothing of importance, other than that the plant has a wide range, great adaptability to such edaphic features, and that it pursues its main role as a pioneer, introduced under special circumstances, in spite of such factors, because they are of no importance.

FREQUENCY CHARTING OF STOEBE ASSOCIATIONS.

A certain amount of reconnaissance work was done in order to trace typical associates of *Stoebe*. Detailed results cannot be given here.

Small circles of half-a-metre diameter were made, and repeated from point to point. *Elionurus argenteus*, *Eragrostis chalcantha*, gave the largest number of frequencies, followed by *Justicia anagalloides*, *Eragrostis brizoides*, *Helichrysum nudifolium*, *Eragrostis chloromelas*, and several dozen other species in very small frequencies. Some attempts were also made to divide the charting areas into grazed, not heavily grazed, and " dry " areas. Analyses circles were laid out by Gillman and continued by the author from year to year.

Unfortunately, the history of these sites was too little known, and although there were permanent circles which could be visited each year, association and mere frequency could not be taken at their face values. To remedy this, quadrats were set up on special areas, such as on a site 15 yards by 1 yard, which was cleared of everything except *Stoebe* seedlings. This was on a ploughed fire-belt. Similar experiments, however, were made over too short a period to obtain the information required.

ROOT STUDIES.

A root bisect was made by Gillman, which showed *Stoebe* roots going down 5 feet, in a clay soil with a M.W.R.C. of about 65%. The plant is usually deep-rooted, or when not deep-rooted, because it is underlain by Iron Sesquioxide, produces a large number of thick laterals. A root-stock is present, from which branches radiate upwards and outwards, and it bears a number of dormant buds, which are also situated on the base of the stems. From the root-stock a thick tap root descends vertically, tapering steadily. Some of the laterals are considerably swollen a short distance away from the root-stock, the whole forming a rhizome-like mass. The swollen laterals are not always seen, but if present, must be removed very carefully from the soil mass. The root-system is extensive with a moderate amount of superficial roots.

A community which was found on the Vaal sand dunes, had, in many cases, fine rootlets attached to the stocks, and near the surface of the sand. In excavating these plants, fusion of roots was seen, much as described by Rigg (1931), for trees growing in a Sphagnum bog. (See also Weaver and Kramer, 1932, p. 80.) Such fusion seems designed for anchorage in the sand.

A comparison with the root-systems of local grasses (Murray and Glover, 1935), was of interest. With the exception of *Hyparrhenia aucta*, the rooting was relatively superficial. There is a faint suggestion that the pioneers or early successional plants have deeper roots and more extensive systems than such plants as *Cymbopogon plurinodis* or *Themeda trinadra*, in the results obtained. All grasses have seeded and even dropped their seed, before *Stoebe* seeds are ripe for dispersal, but to what extent this can be correlated with the water supply factor in the metabolism of these plants, is unknown.

Two attempts were made to test root competition. On one half of an experimental plot, all cover except *Stoebe* was cleared. The other half was not touched. The plot was surrounded by a shallow trench, and watered once a week. This was in April, 1936. Six months later, no beneficial effect could be observed on *Stoebe*, even when compared with outside plants which had received no additional water. Unfortunately, there were late winter rains, and a fall of snow in September. On another site, started at the same time, a plot was surrounded by an 18 inch trench, and the ground outside cleared of all grasses and herbs. No effect was observed on the plants inside the trenched area.

WATER RELATIONS.

Some preliminary experiments were made on the drying-out of twigs, in an incubator, at 23° C. In 3 hours, *Stoebe* lost 14·7%, *Acacia melanoxylon* 18·5%, *Mundulea suberosa* 14·7—17%, *Lachnopylis sp.* 11·8%, *Protea caffra* 12%. It must be remembered that the leaves of *Stoebe* are very small.

Stoebe was tested against *Casuarina cunninghamiana*, which is apparently xerophytic. Entire twigs were used, and left over-night in a bell-jar with a supply of water. At saturation, the twigs of *Casuarina* had a water content of 106—123% on the dry weight, whereas *Stoebe* had 158%. *Stoebe* lost its water more quickly than *Casuarina*, so that it seems more "mesophytic." The dry weight was oven dry weight.

The oil potometer was employed in a number of tests. Consistent results were obtained. Comparisons were made with *Acacia melanoxylon*, the transpiring surfaces being measured volumetrically. Temperature, light and humidity readings were taken continuously.

An attempt was made to seal *Stoebe* plants in large drums, holding 600—700 lbs. of soil, but no simple water-proof cover could be evolved that would stand up to out-door conditions. In the end, the tins were simply covered when it rained. Mature plants could not be used, as they wilted immediately, on removal, and died in a short time. Seedlings were taken from natural seed beds, but even here, in some cases it was necessary to prune the entire upper part of the plant, in order to keep it alive.

ANNUAL COURSE OF WATER CONTENT IN STOEBE CORRELATED WITH FRESH WEIGHT, DRY WEIGHT, AND ASH.

These determinations were made, in part, to determine the extent, and the time of dormancy, in the bush. In summer, as the water content rises, the small leaves become more succulent, and the bush takes on a green colour. In winter, it is a dead gray.

Some gross carbohydrate and nitrogen analyses were made. Nitrogen was found to rise sharply as flowering commenced.

All the figures are, of necessity, of a relative character—while the water is changing, so is the dry weight, and so is the fresh weight, relatively and absolutely. Leaves were also picked, 200 at a time, but it was impossible to pick the same age leaves, and so on. (See Mallery, 1935 and Runyon, 1936.)

While the amount of variation during the year was rather less than expected, there was a distinct, if somewhat irregular, cycle. There is little relative difference between the water content/fresh weight ratio, and the water content/dry weight ratio, except that the latter is more sharply defined. One is able to say, perhaps, that when the plant begins to actively promote synthesis, the contrasts are more marked, thus flattening out the increase in water, by an increase in carbohydrates ; the plant begins to grow, then to flower and to fruit. It may be possible that the water content is high here, and is overtaken to some extent by the dry weight ; as they decline, the water is high proportionally, and then as dormancy comes on, it too falls, while the dry weight is still absolutely low. This receives support from a graph which shows that water really is high, to ash, while the dry weight, at this point, is correspondingly low. In the same way, when both water and dry weight show relative decreases, to the ash, it may be assumed that the ash really has risen. One may also assume that the ash is more inert in general metabolism, than water or dry weight, which appear to be subject to much more pressure from purely external factors. The graph explains little of the behaviour of the ash, but this may be because the analysis is not fine enough to reveal variations which are necessarily small. Of course, when dry weight and water both fall, according to ash weight, they may really have decreased, and are not registering an increase in ash. Sande-Bakhuyzen (1928) gives ratios rather similar to those above, but like them they are also comparative on a sliding scale, and are not given as absolute values.

EFFECT OF REDUCED LIGHT ON STOEBE.

It was decided to test the effect of reduced light on *Stoebe*, because of its habit of establishing itself on old roads, and other exposed places.

Screens built of wood, and 6 by 6 feet, were covered with hessian. The poles were made termite proof, and the ends of the hessian protected by a tarred cloth. The light was reduced to 1/55 and 1/10 normal, severe reductions. In the darker of the screens, termites built a nest, around the plants. They did not appear to attack the plant. The stems broke off as the plants began to die.

In general, there was an appreciable increase in succulency, then the plants began to grey. Elongated, etiolated shoots made an appearance ; they faded, and the plant died from the bottom up. After the removal of the screens, those under the lighter screen recovered, but the area that had been under the darker screen, remained a barren patch. The grass suffered as severely as the bushes.

Another series of screens were erected. The largest was 6 by 4 by 4½ feet, and it was covered with one layer of the finest hessian. Three smaller screens, 3 by 3 by 3 feet were made. One had two thicknesses of hessian, the second one a layer of the finest and one of coarse hessian, and a third one layer of the finest. The above light values had been obtained by one and two layers of hessian. Another screen, 6 by 4½ by 4½ feet, with one end open, was erected over a seed bed. It had one layer of hessian but was too small for its purpose, which was to modify the conditions under which the seedlings might come in and establish themselves.

The small screens were introduced in the hope that such a series might show more clearly the light intensity under which the termites built their nests. Owing to the small size of the screens, when samples were taken for carbohydrate analysis, little was left of the plant.

All the screens had ventilating flaps. Samples were taken for water content, dry weight, nitrogen and nitrates. A few samples were also taken of the soil, since sampling had shown a rather peculiar zonation of the moisture—the first two inches might be quite wet, but underneath this the soil was powdery and dry.

In 3½ months the plants in the darkest screen had been reduced to a few pale etiolated shoots, springing from the main stems. Most of the stems died and broke off. At this time the large screen showed only a slight succulency, the small light screen resembled it ; the medium screen was beginning to grey. At this time a small termite nest had begun to form in the medium screen. At the end of the fourth month the screen was removed from the darkest shaded area. Towards the end of the sixth month, the screens were sampled. Those plants that had been under the dark screen showed dark green shoots, apparently quite normal, although the rest of the plant looked dead. In the large screen the plants were beginning to die, in the small medium screen they were almost dead, and those under the small light screen were severely affected. The grass cover, a mixture of *Eragrostis sp.*, *Hyparrhenia hirta*, *Trachypogon plumosum*, *Themeda triandra*, *Monocymbium ceresiforme*, had all felt the effects of reduced light at least as severely.

In the open screen over the seed bed, fairly young plants were already trailing on the ground, showing a lax, etiolated, growth. Analytical figures cannot be given in detail, but the figures bear out the observations made, to some extent. Atmometers placed within the screens seemed to show increased humidity, due perhaps to decreased wind movement and shading, and this seems to depress easy transpiration, and to be responsible for the succulency. There was considerable variation among the bushes, even those placed under the same conditions.

When the plants begin to die the water content of the shoots drops. This change results in a high ratio of dry weight to ash, but some metabolic changes affect the absolute ash content most markedly, indeed, this feature provides a suitable prognosis. At this point reference might briefly be made to the work of Hasselbring (1914), Muenscher (1922), Loomis (1929), Meyer (1931), Clements (1934), and Freeland (1936), on the question of transpiration and ash content.

One of the most prominent features in the analysis was the appearance of reducing bodies, on inversion, in the alcoholic extract made from plants under the screens. (See True & Hawkins, 1918.) The nitrogen content was very low. The nitrogen content of the root-stock of the small dark screen was clearly very low, and the nitrate content also, while the nitrate content of the stem and leaves was clearly high.

A laboratory experiment was conducted on potted plants placed under screens of hessian, of one and two thicknesses, and transpiration measured. The difference between the dark and light screen was most marked, the dark screen affecting transpiration very considerably.

ERADICATION.

Eradication may be divided into three main sections—fire, poisoning and clearing. There was also one attempt at eradication by a heavy application of mixed fertiliser.

An area 5 by 15 yards was enclosed, and 45 lbs. of PNK was scattered over the bushes and on the ground. The fertiliser was composed of rock and superphosphate, ammonium sulphate and muriate of potash. The plants became vigorously vegetative, and did not flower at all, though plants nearby, which had not been fertilised, flowered normally. The PNK increased the water content of the stems and leaves without affecting the dry weight or the ash content. The small leaves stood up stiffly like little spines, while whorls of leaves crowned the stems.

Firing destroys the seed, but no seasonal burn prevented the vegetative regeneration of the bushes. Besides the simple type of burn, plants were also given a severe burn back. After the preliminary firing, grass and dry stems were piled round the butts of each burnt plant, and the heaps fired. Even this did not kill the buds, except in a few more cases. Annual burning will not kill the plant, but frequent burning would do so.

In one case a protected plot became greatly overgrown with *Cyperaceae* and grasses. The bushes seemed shaded to a large extent, too. In an ensuing fire, they were almost all killed, perhaps by the strength of the fire.

In August, 1933, Gillman burnt a small number of plants. In September of that year, I found four plants with shoots of about ½ inch. In November, there were more plants shooting. The next November, after another veld fire, only half survived. On May 3rd, 1934, 200 plants were burnt on ground which had not been touched for at least three years. The grasses were pioneer species, *Aristida*, *Cynodon* and so on. Thirty-two plants were burnt back, it being noted that they had burnt well in the first firing. In June next year, about 18 of the 32 plants showed no shoots. Of 10 other plants which had burnt particularly well in the first firing, four were showing no shoots.

On September 22nd, 1933, 62 plants were burnt back. On November 18th, 25 showed long shoots, and 11, small shoots. The plants were burnt again on November 30th, and on December 13th, another thirteen were burnt for the first time. Thirty-three were dead on March 17th, 1934. The plot was accidentally burnt in a fire in November, 1934. In June 1936, about two-thirds of the 75 plants were dead.

Actually, these figures give much too vivid a picture of the effects of burning. An ordinary veld fire leads to normal regeneration in almost all cases.

Poisoning. In December 1935, 42 plants were burnt. After allowing regeneration to take place for several weeks, the plants were sprayed with a 5% solution of Sodium chlorate. Thirty plants died. Eight plants which were burnt but not poisoned, were all alive.

Seven plants were augered or slashed, and a solution of Arsenic pentoxide poured in to the wounds. Although the plants were small; no more than two died.

During the locust campaign of 1934, Government officers poisoned a number of bushes with Sodium arsenate. This was on April 12th. The veld cover consisted of *Eragrostis spp.*, *Hyparrhenia hirta*, *Rhynceletrum roseum*, and *Stoebe vulgaris.* The area was burnt on April 26th. Regeneration was normal.

In December 1933, bushes were sprayed with a 5% solution of Potassium chlorate. The spray was directed over the crowns, or at the butts. In April, 1935, 54% were dead. In April, 1934, 20 plants were sprayed with 5%, 20 with 2½%, and 10 with 1¼% solutions. Two months later the apparent mortality was 90%, 90% and 70% respectively. Crown spraying seemed slightly more effective.

In December, 1933, plants were sprayed, butt and crown, with a 10% and a 5% solution of Sodium chlorate. The plants were large, and in good condition. Two months later the apparent mortality was 85% and 70%. In April, 1934, 25 plants in each of three series were sprayed with 5%, 2½% and 1¼% solutions. Two months later the mortality was 76%, 72% and 72%. Crown spraying was twice as effective as butt spraying. The experiment was repeated with 30 plants in each group, 15 plants being sprayed with a gallon, and the time of the experiment was in December, 1934. Two months later the mortality was 87%, 70% and 50%.

Half-a-pound of solid Sod. chlorate was divided among five plants, and dissolved by pouring 4 gallons of water over it. The plants were trenched. All the plants died in a fortnight, turning a peculiar purple colour.

A plot was cleared, and three metre quadrate laid down. 115, 230 and 460 grammes of Sod. chlorate were put down, and covered with soil. A fourth quadrat was left as a check. 18 months later the treated quadrats were all clear, while the check quadrat was overgrown with weeds. However, when used as a spray, as with *Stoebe* plants, the effect of the poisons seemed quite local, and not too persistent.

It was thought that a heavy roller might succeed in seriously damaging the plants. In November, a plot was rolled with a ring roller, ½ ton in weight, and 8 feet in length. In many cases plant stems were broken, but young plants were not affected. When the plants are very dry, a small amount of trampling damages them, but when they are beginning to turn green, they can stand a lot of such treatment.

Ploughing and clearing. Ploughing is one sure means of eradication. The plants are completely uprooted, and no regeneration takes place, but there is a danger that ploughing will open the ground to *Stoebe* seedlings, unless all effective sources of seed are destroyed.

Native hoes were used in clearing, and sharpened spades were effective. Clearing must be done with a little care, since if the superficial portions of the plants are removed, the root-stock can send out new shoots. Small bushes are easy to remove, but large bushes need careful cutting.

100 large, and 100 small plants were cleared with hoes. Some of the large plants had tap roots of 1½ inches diameter, below the root-stock. After a month no regeneration had occurred, but within a year, 4 large plants had sent up shoots, due to superficial clearing. Some root-stocks were removed, and showed no signs of regeneration. The grass cover soon colonised the bare areas left under big bushes.

SOME ANATOMICAL ASPECTS.

Nothing of importance can be added to the statements of Gillman on the anatomy of the plant. It may be added briefly, that the leaves have a thick upper cuticle, which is thinner on the lower side. The epidermis is also thickened. The stomata on the lower surface of the leaf were raised. Two distinct palisade-like rows of cells are present on the upper surface of the leaf. Three bundles were observed.

A micro-chemical examination was made of the stems and the root stock according to Eckerson's mimeographed instructions, but no important information was obtained.

I wish to thank Prof. Phillips, of the University of the Witwatersrand, for his help and advice. Dr. B. Segal, for his advice with chemical matters, and Mr. A. H. Bunting for the great majority of the pH values I obtained.

BRIEF SUMMARY.

A physiological and ecological investigation was made of *Stoebe vulgaris*. Considerable attention was devoted to the germination of seeds under varied conditions, and the question of dispersal was dealt with. The germination conditions of associated and other plants was investigated, in an attempt to trace the significance of laboratory obtained results, against as wide an ecological background as possible.

Soil samples from various *Stoebe* sites were analysed physically and chemically. Information is given as to root studies, and water relations. The history of transects and charting circles is given. Eradication was divided into four groups—trampling and rolling, firing, poisoning and clearing.

SELECTED BIOGRAPHY.

Allison, L. Reduction of organic soil carbon by reduction with chromic acid. Soil Sc. 31. 1931.

Armstrong, H. Origin of osmotic effects. Proc. Roy. Soc. Lond. A. 58. 1906.

Ashby, E. A quantitative analysis of vegetation. Ann. Bot. 779-802. 1935.

Aslander, A. Experiments on the eradication of Canada Thistle, Cirsium arvense, with chlorates and other herbicides. J. Agr. Res. 1-36. 1928.

Aslander, A. Eradication of thistles by means of Sodium chlorate. Svenskt. Land. 19. 903-4. 1935. Herb. Abs. 6. 1. 64.

Atkins, W. Some factors affecting the h-ion concentration in the soil and its relationship to plant distribution. Proc. Roy. Soc. Dublin. 1922.

Baldwin, H. Alcohol separation of empty seeds. Amer. J. Bot. 19. 1. 1-12. 1932.

Baver, L. Effect of organic matter on several physical properties of the soil. J. Am. Soc. Agron. 22. 703-708. 1930.

Blair G. and Yates, F. Effect of climatic variation on the plasticity of soils. J. Agr. Sc. 22. 639-646. 1932.

Bouyoucos, C. Mechanical analysis of soils. Soil. Sc. 25. p. 573. 1928.

—— A comparison of the hydrometer method and the pipette method for making soil analysis. J. Am. Soc. Agron. 22. 747-751. 1930.

Boynton, M. Observations on the dissemination of seeds. Bot. Gaz. 20. 502-503. 1895.

Braun, H. A gradient of permeability to iodine in wheat seed. J. Agr. Res. 38. 2. 225-227. 1924.

Brigg, L. and Shantz, H. Wax seal method for determining the lower limit of available moisture. Bot. Gaz. 51. 210-219. 1911.

Brown, H. Selective permeability of some seeds of the Gramineae. Proc. Roy. Soc. Lond. B. 81. 82-93. 1909.

Brown, A. and Tinker, E. Absorption of phenolic solutions by seeds of Hordeum vulgare. Proc. Roy. Soc. B. 89. 119-135. 1915-17.

Brown, R. Absorption of solute from aqueous solution by seeds of wheat. Ann. Bot. 461 571-581. 1932.

Burd, J. Chemical criteria, crop production and physical classification of two soil types. J. Agr. Res. 12. 298-309. 1918.

Burrell, R. and Phillips, T. Determination of nitrate nitrogen in plants. J. Biol. Chem. 65. 229-234. 1925.

Camp, A. and others. Effect of soil temperature on germination of citrus seeds. Amer. Journ. Bot. 20. 348-353. 1933.

Campbell, E. Nitrogen content of weeds. Bot. Gaz. 78. 1. 103-115. 1924.

—— Carbohydrates, determination of. Plant. Phys. 2. 387-392. 1935.

Chibnall, A. Distribution of nitrogen in the leaves of runner bean. Biochem. Journ. 16. 31. 344-362. 1922.

Chippindale, H. Effect of some chemicals on Cocksfoot. Ann. App. Biol. 20. 3. 369-376. 1933.

Cholodny, N. On the germination hormone of Gramineae. Planta. 289-312. 1933.

Clements, F. Plant Physiology and Ecology. 1907.

—— Plant Succession. 1916.

—— Plant Indicators. 1920.

—— Relict method in ecology. Journ. Ecol. 22. 1. 39-68. 1935.

Clements, F. and Goldsmith, G. The Phytometer Method in Ecology. 1924.

Clements, F. and others. Plant Competition. 1929.

Clements, F. and Long, F. Factors in elongation and expansion under reduced light intensity. Plant. Phys. 9. 4. 767-781. 1934.

Clements, F. and Martin, E. Effect of soil temperature on transpiration of Helianthus annuus. Plant. Phys. 9. 619-630. 1934.

Clements, F. and Weaver. Experimental Vegetation. 1924.

Clements, H. Significance of transpiration. Plant. Phys. 9. 1. 165-172. 1934.

Cohen, C. Stoebe sp. Journal of S.A. Botany. Oct. 1935. Some aspects of the reproduction of Stoebe vulgaris and certain local grass and weed seeds. S.A. Journ. of Sc. 33. 351-54. 1936.

Collins, E. Structure of the integumental system of barley grain in relation to localized water absorption and seed permeability. Ann. Not. 32. 381-414. 1918.

Crafts, A. Physiological problems connected with the use of Sodium chlorate, in weed control. Plant Phys. 10. 4. 699-730. 1935.

Crafts, A. Factors influencing the effectiveness of Sodium chlorate as a herbicide. Hilgardia. 9. 9. 437-456. 1935.

—— Toxicity of Sodium arsenite and Sodium chlorate in California soils. Hilgardia. 9. 9. 460-497. 1935.

Crocker, W. Mechanics of dormancy in seeds. J. Agr. Res. 3. 2. 99-120. 1916.

—— Effect of light on germination of seeds. Biological Effects of Radiation. Ed. Duggar. Vol. 2. p. 817. 1936.

Crocker, W. and Harrington, C. Catalase and oxidase content of seeds, in relation to their dormancy, age, vitality and respiration. J. Agr. Res. 15. 137-174. 1918.

Daish, W. Cupric reducing power of pentoses, xyloses and arabinose. J. Agr. Sc. 6. 3. 255-262. 1914.

Davis, W. and Daish, W. Study of the methods of estimation of carbohydrates, especially in plant extracts. J. Agr. Sc. 437-468. 1912-13.

Davidson, O. and others. Preparation of aqueous extracts of soluble nitrogen from plant tissue. Plant. Phys. 9. 4. 817-22. 1934.

—— Determination of the nitrogenous fractions in the vegetative tissue of the Peach. Plant. Phys. 10. 1. 73-92. 1935.

Davis, O. Germination and growth of Cornus florida, Sambucus canadensis, and Berberis Thunbergi. Bot. Gaz. 84. 3. 225-261. 1927.

Davis, W. Resistance of seed coats of Abutilon Theophrasti to intake of water. Bot. Gaz. 64. 166-167. 1912.

—— Primary dormancy of, and after-ripening, and secondary dormancy in Ambrosia trifida. Amer. J. Bot. 17. 1. 58-77. 1930.

—— Development of dormancy in seeds of Cocklebur. Amer. J. Bot. 17. 1. 77-88. 1930.

Denny, F. Permeability in seeds. Bot. Gaz. 63. 468-485. 1917.

Desai, B. Effect of certain nutrient deficiencies in measuring stomatal behaviour. Amer. J. Bot. 22. 10. 915. 1935.

Dixon, H. Resistance of seeds to high temperature. Ann. Bot. 590-1. 1902.

Dustman, R. Inherent factors relating to the absorption of mineral elements in plants. Bot. Gaz. 79. 3. 233-264. 1925. .

Duvel, J. Vitality and germination of seeds. U.S.A. Dept. Agric. Bull. Plant Ind. 58. 1904.

ECKERSON, S. Protein synthesis in plants. Nitrate reduction. Bot. Gaz. 77. 377-90. 1924.

—— Conditions affecting nitrate reduction in plants. Contrib. Boyce Thompson Instit. 4. 119-130. 1932.

—— Microchemistry. Mimeographed copy.

EDEN, T. Edaphic factors accompanying the succession after burning on Harpenden Common. J. Ecol. 12. 2. 267-86. 1924.

EMMETT, H. and ASHBY, E. Some observations on the relation between H-ion concentration of the soil and plant distribution. Ann. Bot. 48. 867-86. 1934.

FEHER, D. Plant associations as indicators of value of sandy soils. Z. Pflanz. Dungung Bodenk. 4. 129-137. 1935.

FREELAND, R. Effect of transpiration on the absorption and distribution and mineral salts in plants. Journ. Amer. Bot. 23. 5. 355-62. 1936.

GAINEY, P. and METZLER, L. Some factors affecting nitrate-nitrogen accumulation in soils. J. Agr. Res. 11. 43-64. 1917.

GAINEY, P. and others. Nitrogen balance in semi-arid Western Kansas soils. J. Amer. Soc. Agron. 21. 1130-53. 1929.

GARDNER, W. Effect of light on the germination of light sensitive seeds. Bot. Gaz. 71. 249-88. 1921.

GEISLER, S. Soil reactions in relation to plant successions. Ecol. 7. 163-84. 1926.

GILLMAN, H. Stoebe cinerea. M.Sc. Thesis, Wits. Unpublished. 1934.

GORTNER, R. Some data on humus, humus carbon, and humus nitrogen. Soil Sc. 2. 539-548. 1916.

HAASIS, F. Germinative energy of lots of coniferous tree seeds, as related to the incubation temperature, and to duration of incubation. Plant. Phys. 3. 4. 365-412. 1928.

HAFENRICHTER, A. Respiration of the Soybean. Bot. Gaz. 85. 3. 271-97. 1928.

HAINES, F. A soil survey of Hindhead Common. J. Ecol. 14. 1. 33-71. 1926.

HALVERSEN, W. Value of tho nitrification test. Soil. Sc. 26. 221-31. 1928.

HARDY, F. Index of soil textures. J. Agr. Sc. 18. 252-56. 1928.

HARPER, H. Use of Sodium chlorate in the control of Johnson grass. J. Am. Soc. Agron. 18. 407-12. 1926.

HARRINGTON, G. Forcing the germination of freshly harvested wheat and other cereals. J. Agr. Res. 23. 2. 79-98. 1923.

—— Use of alternating temperatures in the germination of seeds. J. Agr. Res. 23. 5. 295-323. 1923.

HASSELBRING, H. Transpiration stream and absorption of salts. Bot. Gaz. 57. 72-93. 1914.

HATTES, C. and WILSON, R. Resistance of wheat seed to high temperatures under different conditions of heating. J. Am. Soc. Agron. 22. 108-12. 1930.

HOLME, R. Note on the use of alcohol as a sugar extract in plant tissue. Biochem. Journ. 27. 116. 1933.

HOWARD, W. An experimental study of the rest period in plants. Seeds. Miss. Agr. Expt. St. Res. Bull. 17. 58 pp. 1915.

HULBERT, H. and others. Controlling perennial weeds with chlorates. J. Am. Soc. Agron. 18. 423-33. 1926.

HURD, A. Injury to wheat seed, resulting from drying after disinfection with formaldehyde. J. Agr. Res. 20. 209-44. 1921.

JENNY, H. Clay content of soil in relation to climatic factors, particularly temperature. Soil. Sc. 40. 111-28. 1935.

JENNY, H. and LEONARD, C. Functional relationships between soil properties and rainfall. Soil. Sc. 38. 363-81. 1934.

JODIDI, S. Nitrogen metabolism in etiolated corn seedlings. J. Agr. Res. 31. 12. 1149-63. 1925.

JODIDI, S. and others. Nitrogen metabolism in normal and blighted spinach. J. Agr. Res. 15. 7. 385-405. 1918.

JOHNSON, J. Influence of heated soils on seed germination. Soil Sc. 7. 1-87. 1919.

JUBY, D. and PHEASANT, J. Intermittent germination as illustrated by Helianthum guttatum. Journ. Ecol. 21. 2. 442-51. 1933.

KEEN, B. Hydrometer method for studying soils. Soil Sc. 26. 273. 1928.

—— Physical Properties of the Soil. 1931.

KEEN, B. and COUTTS, J. Single value soil properties. J. Agr. Sc. 18. 740-55. 1928.

KELLEY, A. Plant indicators of soil types. Soil Sc. 13. 411-32. 1922.

—— Soil acidity, an ecological factor. Soil Sc. 16. 41-54. 1923.

KIDD, F. Controlling influence of Carbon dioxide on maturation and germination of seeds. Proc. Roy. Soc. Lond. B. 87. 408-21. 1914. B. 87. Part 2. 402-25. 1914. B. 89. Part 3. 136-57. 1917.

KIDD, F. and WEST, G. Production of secondary dormancy in seeds of Brassica alba following treatment with Carbon dioxide and relation of this phenomenon to the question of stimulation of growth processes. Ann. Bot. 31. 457-85. 1917.

KURZ, H. H-ion concentration in relation to ecological factors. Bot. Gaz. 76. 1-29. 1923.

LALLEMAND, S. and LALLEMAND, S. Toxicity of ethyl alcohol for dormant and germinating seeds. Chim. Biol. 17, 1509. 1935.

LEVYNS, M. R. Germination of some S.A. seeds. J. S.A. Bot. 161-170. 1935.

—— A revision of Stoebe L. Journ. S.A. Bot. 3. 1. 1937.

LINK, E. and SCHULZ, S. Effects of the method of desiccation on the nitrogenous constituents of plant tissues. J. Am. Chen. Soc. 46. 2044-50. 1924.

LINK, E. and TOTTINGHAM, W. Effects of the method of desiccation on the carbohydrates of plants. J. Am. Chem. Soc. 43. 439-47. 1923.

LOOMIS, W. Schloessings experiments on the relation of transpiration to the translocation of minerals. Plant. Phys. 4. 1. 158-60. 1929.

MALLERY, T. Changes in the osmotic value of the expressed sap of leaves and small twigs of Larrea tridentata as influenced by environmental conditions. Ecol. Monog. 5. 1. 1-35. 1935.

MARSHALL, C. Colloids in Agriculture. 1935.

MAXIMOV, N. Physiological significance of the xeromorphic structures of plants. Journ. Ecol. 19. 273-82. 1931.

MEYER, B. Effect of mineral salts on the transpiration and water requirements of Cotton plants. Amer. J. Bot. 18. p. 79. 1931.

MIDDLESTON, H. Properties of soils which influence soil erosion. U.S.A. Dept. Agric. Tech. Bull. 78. 16 pp. 1930.

MITCHELL, J. Origin, nature and importance of soil organic constituents having base exchange properties. J. Am. Soc. Agron. 24. 256-75. 1932.

MORINAGA, T. Germination of Rice. Bot. Gaz. 77. 1. 73-84. 1925.

MUENSCHER, W. Effect of transpiration on absorption of salts by plants. Amer. J. Bot. 9. 311-29. 1922.

MURRAY, S. and GLOVER, P. A preliminary study of the root development of certain S.A. Highveld grasses. Journ. S.A. Bot. 1. 65. 70. 1935.

Orcutt, F. and Wilson, P. Effect of nitrate-nitrogen on carbohydrate metabolism in inoculated Soybeans. Soil. Sc. 39. 289-96. 1935.

Osborn, J. Physical properties of Natal Wattle soils. S.A. Journ. Sc. 28. 207-21. 1931.

Pearsall, W. Note on Olsen's work on H-ion concentration in soils. J. Ecol. 12. 139. 1919.

Pearsall, W. and Ewing, J. Relation of nitrogen metabolism to plant succulence. 43. 27-34. 1929.

Phillips, J. Principal forest types in the Knysna region. S.A. Journ. Sc. 25. 188-201. 1928.

—— Forest succession and ecology in the Knysna region. Mem. 14. Bot. Survey of S.A. 1931.

Pickering, U. Studies in germination and plant growth. J. Agr. Sc. 4. Part 2. p. 411. 1908.

van der Plank, E. Estimation of sugar in the leaf of the Mangold. Biochem. Journ. 30. 3. 457-83. 1935.

Pierre, W. Factors affecting the growth of plants on acid soils. Soil Sc. 311. 183-207.

Potapov, A. Soil acidity as a phytopedological factor. Soil Sc. 35. 35-73. 1933.

Puri, N. Exchangeable bases in soils. Soil Sc. 40. 159-63. 1935.

Raleigh, G. Chemical conditions in maturation, dormancy and germination of seeds of Gymnocladus dioica. Bot. Gaz. 89. 3. 273-93. 1930.

Ranjan, S. and Mallik, A. A study of the catalase reaction with special reference to respiration in plants. New. Phyt. 30. 5. 355-81. 1931.

Redington, G. Effects of duration of light on growth and development of plants. Biol. Revs. 4. 2. 180-208. 1929.

Rhine, L. Divergence of catalase and respiration in germination. Bot. Gaz. 58. 1. 46-67. 1924.

Ridley, H. N. Dispersal of Seeds through the World. 1925.

Rigg, G. Some Sphagnum bogs of the North Pacific coast of America. Ecol. 6. 260-278. 1925.

Robinson, G. Physical properties of soil in relation to soil survey work. Trans. Far. Soc. 17. 2. 224-227. 1922.

Robinson, G. Soils. 1932.

Rudolfs, W. Effect of salt concentration having a definite osmotic effect on absorption by seeds. Soil. Sc. 11. 277-93. 1921.

—— Effect of seeds on H-ion concentration equilibrium in solution. J. Agr. Res. 30. 11. 1021-26. 1925.

Runyon, E. Ratio of water content to dry weight in leaves of Creosote bush. Bot. Gaz. 97. 3. 518-542. 1936.

Russell, E. Soil Conditions and Plant Growth. 1927.

Salisbury, E. Stratification and H-ion concentration in relation to soil reaction. J. Ecol. 19. 1. 120-140. 1922.

—— Incidence of species in relation to soil reaction. J. Ecol. 13. 1. 149-160. 1925.

Sande-Bakhuyzen, H. van de. Study of wheat grown under constant conditions. 3. 1. 1-30. 1928.

Sessions, H. and Shive, J. A method for the determination of inorganic nitrogen in plant extracts. Plant Phys. 3. 4. 499-511. 1928.

Shantz, H. and others. Indicator significance of vegetation in Toole Valley. J. Agr. Res. 1. 365. 1914.

—— Soil moisture in relation to growth of crop plants. J. Am. Soc. Agron. 17. 705-11. 1925.

Shive, J. Relation of soil moisture to physiological salt balance in plants. New Jersey Agr. Expt. St. Rept. 385-363. 1919.

Shull, C. Semi-permeability in seed coats. Bot. Gaz. 56. 169-199. 1913.

—— Temperature and rate of absorption of moisture. Bot. Gaz. 69. 361-390. 1920.

Shull, C. and Davis, W. Delayed germination and catalase activity of Xanthium. Bot. Gaz. 75. 3. 268-281. 1923.

Shull, C. and Shull, S. Irregularities in rate of absorption by dry plant tissues. Bot. Gaz. 93. 4. 376-399. 1932.

Stiles, W. and Leach, W. Variations in respiratory ratio of seeds with different food reserves. Proc. Roy. Soc. Lond. B. 113. 405-438. 1933.

Strowd, W. Determination of nitrites and nitrates in plant tissues. Soil Sc. 10. 343-356. 1920.

Sweet, O. Carbohydrate-Nitrogen and base elements relationships of peas grown in water cultures under various light exposures. Plant Phys. 9. 2. 301-322. 1934.

Tam, R. and Magistad, O. Relationship between nitrogen fertilization and chlorophyll content in pineapple plant. Plant. Phys. 10. 1. 159-168. 1935.

Tansley, A. Use and abuse of vegetational concepts and terms in ecology. Ecol. 16. 3. 284-307. 1935.

Tharp, W. Developmental anatomy and relative permeability of barley seed coats. Bot. Gaz. 97. 247-271. 1935.

Thornton, N. Carbon dioxide storage. Germination of lettuce seeds at high temperatures in both light and darkness. Contrib. Boyce-Thompson Instit. 8. 1. 25-40. 1936.

Thomas, W. Influence of desiccation temperature on water-soluble nitrogenous constituents, and separation of water-soluble protein from non-protein constituents. Plant Phys. 2. 1. 55-66. 1927.

—— Effect of Sodium nitrate applications on the total nitrogen and its partition products in the leaves, new and one year old branches, throughout a year's cycle. Plant Phys. 2. 3. 240-272. 1927.

Tincker, M. Sodium chlorate as a weed-killer. Journ. Roy. Hort. Soc. 59. 107-118. 1934.

Tottingham, W. and Lowsma, H. Effects of light on nitrate assimilation. J. Am. Chem. Soc. 50. 2436-45. 1928.

True, H. and Hawkins, L. Carbohydrate production in healthy and blighted spinach. J. Agr. Res. 15. 7. 381-384. 1918.

Tulaikov, N. Utilization of soil moisture by plants. Soil Sc. 24. 1926.

—— Use of water by cultivated plants in the field. J. Agr. Sc. 19. 1-16. 1929.

Turner, T. Studies in the mechanisms of the physiological effects of certain mineral salts in altering the ratio of top growth to root growth. Amer. J. Bot. 9. 415-446. 1922.

—— Nitrogen supply and tops and roots in flax. Soil Sc. 24. 303. 1926.

Ungerer, E. Effect of Sodium chlorate on plant and soil. Z. Pflanz., Dungung Bodenk. 39. 156. 1-34. 1935.

Vassiliev, I. and Vassiliev, M. Changes in the carbohydrate content of the wheat plant during the process of hardening for drought resistance. Plant Phys. 11. 1. 115-125. 1936.

Vickery, H. Basic nitrogen of plant extracts. Plant Phys. 2. 303-312. 1927.

Walkley, A. An examination of the methods for determining Carbon and Nitrogen of the soil. J. Agr. Sc. 25. 598-601. 1935.

Walkley, A. and Black, I. An examination of the Dagljareff method for the determination of organic matter and a proposed modification of the chromic acid titration. Soil Sc. 37. 29-37. 1934.

Walster, H. Formative effects of high and low temperatures. Bot. Gaz. 69. 97-126. 1920.

Waksman, S. Microbiological analysis as an indication of soil fertility. Soil Sc. 14. 321-346. 1922.

——. Origin and nature of soil organic matter or humus. Soil. Sc. 22. 221-232. 1926.

Warington, K. The effect of constant and fluctuating temperatures on the germination of weed seeds of arable soil. J. Ecol. 24. 185-204. 1936.

Waterman, W. Development of plant communities on a sand ridge region in Michigan. Bot. Gaz. 74. 1. 1-30. 1922.

Weaver, J. Underground development of plants in relation to grazing. Ecol. 11. 3. 543-557. 1930.

Webster, J. Nitrogen metabolism in the Soybean. Plant Phys. 3. 1. 31-44. 1928.

Wherry, E. Soil acidity. Smithsonian Report. 247-268. 1920.

Whitfield, C. Ecological aspects of transpiration. Bot. Gaz. 93. 4. 436-451. 1932.

Wilson, J. Calcium hypochlorite as a seed sterilizer. Am. J. Bot. 2. 420-425. 1915.

Yapp, R. H. Concept of habitat. J. Ecol. 10. 1. 1-17. 1922.

Yemm, E. Carbohydrate concentration and CO_2 production in starving leaves. Proc. Roy. Soc. Lond. B. 806. 504-25. 1935.